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Refereed paper

Usability of computerised physician order entry in primary care: assessing ePrescribing with a new evaluation model

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ABSTRACT

Background The incorrect use of medications may result from improper prescribing. The poor interface and design of computerised physician order entry (CPOE) systems may contribute. To improve the quality of electronic drug prescription, ePrescribing, there is a need for an evaluation model that is able to assess the quality of the CPOE, focusing on usability.

Objective To develop and apply a model to evaluate the usability of different CPOEs used for ePrescribing in electronic health records (EHRs) in primary care.

Method An evaluation model for CPOEs was designed by assembling existing quality criteria for ePrescribing, supplemented with new criteria. The evaluation model was used to assess CPOEs from seven EHRs in primary care.

Results The evaluation model included five categories comprising 73 single criteria. The model was found to be easy to use, and facilitated the assessment process. Evaluation of the EHRs revealed differences and similarities between the systems. None of the CPOEs was perfect in that all of them had distinct shortcomings. The most prominent deficiencies were a non-intuitive interface and incorrect dosage function.

Conclusion The model developed might be used not only to evaluate usability in ePrescribing, but also as a basis for studying the usability of other CPOEs. To reduce the risk of drugs being prescribed with incorrect dosages, the most urgent improvement is the development of a more consistent and intuitive interface for the EHRs and an improvement in the dosage function.

Keywords: computerised, electronic prescribing, medical record system, primary health care, program evaluation/methods

What this paper adds

- A new evaluation model for studying the usability of computerised order entry (CPOE).
- Criteria for the assessment of ePrescribing are defined.
- Application of the model reveals shortcomings among different CPOEs.
- By fixing the deficiencies identified, patient safety might be improved and frustration among users reduced.
- The evaluation model might be employed for the assessment of new and updated CPOEs in other areas than ePrescribing.

Introduction

Drugs that are incorrectly prescribed increase risk for the patient affected and are a considerable cost to society.[1] Examples of prescription errors may be incorrect dose formulation,[2] incorrect treatment duration, the absence of clear instructions to the patient[3] and prescription to the wrong patient.[4]

The use of electronic prescribing, ePrescribing, is increasing worldwide, often accompanied by decision support systems. These support systems may reduce the medical risks of medication, thereby contributing to the increased quality of the prescription.[2,5–8] In spite of the many benefits of ePrescribing,[8] there are also risks.[9] The lack of quality in electronic prescriptions is primarily due to shortcomings in the computerised physician order entry (CPOE) within the electronic health record (EHR).[1,10,11] CPOEs in various EHRs differ with respect to design of the user interface and functionality.

The term usability describes the requirements of a system and implies the ease with which a product or system can be used to help the user achieve the desired goal.[12,13] This also implies that usability requires a certain degree of user-friendliness.[14,15]

In order to improve the quality of ePrescribing, there is a need to evaluate different CPOEs in a systematic fashion.[16] Prescribers' perceptions of the features found in their CPOE differ between users within the same EHR,[17] often due to the fact that there are shortcomings in the system's usability.

Objective

The objective of this study was to develop a method to evaluate the usability of CPOEs for ePrescribing. The method was then applied to assess EHRs used in primary care.

Materials and methods

First, in order to formulate quality criteria for ePrescribing, we designed an evaluation model for CPOEs by assembling quality criteria from different sources, supplemented with new criteria. Second, we applied the evaluation model to assess CPOEs for ePrescribing in seven EHRs in primary care in Sweden.

Materials

The most frequently utilised EHRs in primary care were selected: Cosmic 7.2 (Cambio Health Care Systems), Journal III version 1828 (Profdoc), Medidoc version 5.9.1.9 (Profdoc), Swedestar version 4.9.006 (Tieto), SYSteam Cross version 4.13.411, Take Care (Profdoc) and VAS version 10.1B02 (Norrbotten County Council). Assessment was made at seven Swedish primary care centres.

Method

Development of an evaluation model

We designed ePrescribing quality criteria by assembling criteria from four sources: (1) e-lak's quality description of the basic requirements for an IT support for quality improvement of ePrescribing;[10] (2) the Medical Products Agency's prescription requirements (LFVS 1997:10);[18] (3) an expert consensus for comparison of ePrescribing systems;[16] and (4) based on the authors' own experiences of what facilitates and hinders ePrescribing, new criteria were added. All criteria, except those assessing the number of mouse clicks needed to make a prescription, were answered with a yes/no. The quality criteria were initially categorised based on the requirements of the medically qualified prescriber, i.e. that focus on usability and those that (or criteria that) have to do with absolute requirements on the suppliers of EHRs. These criteria were categorised and re-categorised during the study until they finally fell into stable positions and the categories thus became definite. When a criterion belonged to several groups, it was placed according to its principal characteristic. The model was developed iteratively during the study, which meant that the development and evaluation continued in parallel until all the included CPOEs had been assessed in the same way. In total, combination of the four sources resulted in 73 criteria (Appendix A).

Assessment of prescription modules

The assessment of the CPOEs was carried out in November–December 2008, using the evaluation model, which is described as the first level of the results.

Interviews with prescribers

In addition to assessment of the various CPOEs, prescribing primary care physicians were interviewed about their experiences and attitudes to the various CPOEs. The questions asked were:

- What do you think is good with your CPOE?
- What do you think is bad with your CPOE?
- What would you like to improve on your CPOE?

The interviews regarding the respective CPOEs included between one and four physicians, with a

majority of women, except for Swedestar where men formed the majority in the sample. All interviews were recorded using a digital Dictaphone and transcribed verbatim. The answers were grouped according to their face values without any further analysis.

All reviews of the EHRs and interviews with prescribers were made by one of the authors (LJH).

Results

The evaluation model

The model was found to be easy to use, and facilitated the process of assessment.

The evaluation model included the following five categories of quality criteria which all concern the usability of the CPOE:

- Safety refers to features that affect the quality of the completed prescription and, from a patient point of view, contribute to a safer prescription.
- Prescription support includes features that make prescribing itself easier.
- Decision support includes indicators and functions that facilitate correct decisions regarding the prescription.
- User-friendliness refers to how intuitive and easy the systems are to use.
- Patient support refers to functions in the EHR that facilitate use of the drug for patients.

The evaluation

Evaluation of the EHRs revealed differences and similarities between the different systems. None of the CPOEs was perfect in that all had distinct shortcomings. The most prominent deficiencies were non-intuitive interfaces and incorrect dosage function.

By applying the different criteria in the evaluating model, the results below were obtained in the different categories.

Safety

Only one patient could be dealt with at the same time in all but one of the EHRs' CPOE. The exception was Medidoc, in which two patient views could be displayed simultaneously. For all systems, the patient identity was clearly displayed in the upper left-hand corner and throughout the whole prescription process. Recording the reason for the prescription was mandatory in the Take Care system only. The dosage was prescribed in more or less free text in the majority of the systems. In Cosmic and Take Care, it was possible to use different fixed dose windows for different types of prescription, such as until further notice, if necessary, periodic and on–off prescription. The cancellation of prescriptions was possible in all EHRs, and in all of the systems except Swedestar this feature was intuitive. None of the systems had two-way communication with the pharmacy.

Prescription support

The reason for the termination of a prescription could be entered in all systems except Swedestar and SYSteam Cross and was only mandatory in Take Care. Duration of treatment was automatically included when the drug was prescribed for a limited time in Swedestar and VAS. In Cosmic, the prescriber had to tap a small box to include the duration of treatment, and in the other systems, it had to be presented in free text where the dosage was prescribed. The renewal of all medications just took a few mouse clicks in Cosmic and Medidoc only. The recommended drugs were displayed in all of the systems. Only VAS alerted the prescriber to when a non-recommended drug was being prescribed.

Decision support

Allergy warnings were imperfect in many of the systems and only linked to the actual prescription in Medidoc and Cosmic. Integration with web-based FASS existed in all systems except for VAS and Swedestar. In SYSteam Cross it was not web-based, but linked to the Swedish Information System for Medicines (SIL). Integration with Janus existed in Journal III, Medidoc and Take Care. The SIL was used in database format in Medidoc and SYSteam Cross only. However, most of the other suppliers of EHRs were working to integrate this function. Coordination between decision support and a list of laboratory tests did not exist in any of the systems; thus, warnings could not be linked to current liver or renal function tests.

User-friendliness

The number of mouse clicks needed to make a new prescription varied between five and 15. In Swedestar and Journal III, five mouse clicks only were required, contrasting with 15 in Take Care; the average in the other systems was eight. Repeat prescribing was easier than a new prescription in all systems, although Medidoc demanded an equal number of mouse clicks for repeats as for new prescriptions. Usually, between four and five mouse clicks were required, Take Care being an exception requiring nine. The user interface of VAS was inferior to the other EHRs with several different shades of grey and the dosages written with

too many zeros. For example, 20 mg was presented as 0020.000 MG which was considered as being indistinct. The systems that use the right mouse button, as Cosmic and partly also SYSteam Cross, were less intuitive than those designed to use icons. Apart from VAS, the interfaces were fairly equivalent in the different systems and in all systems there was room for improvement.

Patient support

It was possible to print a paper copy of the list of medications for the patient in all of the systems. This list was informative and explicit in all systems except for Swedestar, where it was messy and difficult for the patient to read.

Summary of the CPOEs' characteristics for ePrescribing

Evaluation of the seven CPOEs is summarised as follows:

- Cosmic: Fairly safe, but not intuitive. Not entirely suited for primary care.
- Journal III: Easy to use with a few simple mouse clicks, but lacking important features.
- Medidoc: Easy to use with relatively few mouse clicks, but lacking some important features.
- Swedestar: Easy to use with a few simple mouse clicks, but lacking important features.
- SYSteam Cross: Fairly easy to use with relatively few mouse clicks, but lacking some important features.
- Take Care: Fairly safe and intuitive, but many mouse clicks. Not entirely suited for primary care.
- VAS: Poor interface, lacking some important features.

The interviews

In a few cases, the prescribers contributed to new approaches in the creation of the evaluation model. The interviews showed that physicians who had worked with the same system for a long time were content, whereas those who had recently switched systems were generally very dissatisfied. Changes in the system had generally been from one used in primary care only to one that was the same for both primary and inpatient care.

Discussion

We found that the evaluation model developed in this study can be utilised as a basis for studying the usability of CPOEs for ePrescribing. It was easy to use and revealed differences and similarities between the different systems. We found that no system was perfect, and that all had different shortcomings.

The components of the evaluation model

The quality criteria were likely to be reliable and valid because they were derived from three authority-like influential sources, and several of the quality criteria were present in more than one source. Although the list was extensive, new quality criteria were added in all groups as further key areas were identified. In the domains of decision support and user-friendliness, the majority of the criteria were new. These criteria helped anchor the evaluation model in the reality of prescribing doctors. Some of the flaws with the existing systems may have been because these new criteria have been overlooked. When assessing the CPOEs of the seven EHRs, the evaluation model was easy to use, and facilitated the assessment process.

Limitations of the evaluation process

Some functions could not be checked by the authors during the evaluation. In order to assess how the EHRs deal with any disruptions in the electronic prescriptions service, or how shutdowns affect the electronic prescriptions, it was necessary to ask the system operators and/or EHR suppliers. Thus, the description of these functions is provided by the vendors and cannot be independently validated by the authors.

All system checks and interviews were carried out by one of the authors only. Although, we cannot exclude some variation between different observers, we believe that this would be small because most of the criteria were rather robust, had been used previously and the questions were standardised.

The assessment

Safety

Many of the shortcomings of the electronic prescriptions might jeopardise patient safety because of misunderstandings. We found that the interface and dosage were of particular importance. The only feature that we found similar in the various CPOEs was the

location of the personal code number and name of the patient.

In most of the systems, the dosage was presented in free text. This may result in prescriptions being issued that lack important information for the patient. Different abbreviations that may or may not be commonly known may result in a wrong interpretation at the pharmacy. Several studies suggest that incorrect dosage is the most common prescription error.[19,20]

Prescription support

Only in Swedestar and VAS was the duration of treatment automatically printed on the prescription, making it time-limited. This means that very often a pharmacist cannot verify that a prescription is valid and has to contact the prescribing doctor. With no time limit for the period of use, the medication list will often contain prescriptions that are out of date.

In two of the EHRs, renewal of the complete medication list was possible with very few mouse clicks. Although time-saving, this may also make it quite easy to continue prescribing medications without really considering their benefits, potential harms or interactions.

Decision support

Allergy warnings were linked to prescription issue in only two of the EHRs. Hence there is high risk of potentially dangerous prescriptions in the other EHRs, especially if the prescribers are not aware of this deficiency in allergy warnings.

User-friendliness

The large number of mouse clicks required to make a prescription implies redundant time for the physician who furthermore runs the risk of developing 'mouse elbow'. Achieving a balance between simplicity for the prescriber and patient safety can be difficult. The system with the most safety catches and mandatory elements, and thus potentially the most safe, was Take Care. However, it was also the system that required the most number of mouse clicks and was experienced as the most cumbersome by users. To meet the needs of the prescribers, more intuitive systems have to be developed and an improvement in the dosage function is needed to reduce the risk of drugs being prescribed at the incorrect dosage.

The interviews

The number of interviews within the various systems was low, and the accounts should be regarded as adding views on the issue of evaluating EHRs rather than as generalisable results. In future surveys, we believe that it is of the utmost importance that users' experiences and views are covered systematically

We found it interesting that those who had worked for a long time in the same EHR were satisfied, whereas those who had recently changed systems were generally very dissatisfied. Other studies have shown similar results.[7,21] This is probably because people usually resist being forced to learn new things, but it might also be ascribed to home blindness. Gradually, one adapts even to systems that are cumbersome and lack important features.

The fact that the interviews did not contribute more to a deepening of the understanding of the EHRs may indicate that the evaluation model in itself is sufficient to evaluate the CPOEs.

Practical use and the future of the evaluation model

The evaluation model presented in this study is suggested for use in recurrent quality assessments of the CPOEs within ePrescribing. The model might ultimately contribute to a higher quality in the prescription of drugs, increase patient safety and reduce costs to society.

In future, similar evaluation models could be applied for other parts of the EHR. This type of model that uses standardised criteria might be used when the authorities[22] certify new systems – in addition to testing systems in simulated and live environments[23] – and also during purchasing or upgrading since it facilitates the detection of differences between the systems. In the long run, this could put pressure on suppliers and increase the awareness of the purchasers.

We emphasise that the suppliers of EHRs continue to improve their CPOEs and that prescribers are involved in this development.

From this study, the most urgent improvements needed in the CPOE for ePrescribing are development towards a more consistent and intuitive interface and an improvement in the dosage function.

Conclusion

The evaluation model developed in this study can be used as a basis for studying the usability of CPOEs for electronic prescriptions. The evaluation method was easy to use and identified differences and similarities between the systems.

No system was perfect, and all had some deficiencies. Some of the existing deficiencies may pose

a risk to patients and are a burden and nuisance for prescribers in their daily work.

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Appendix A

Assessment of usability for ePrescribing in electronic health records with a new evaluation model

Source (Reference)	Criteria of usability
	Safety
e-lak[4] [a] Bell *et al.*[10]	Is the name and personal code number presented clearly?
Bell *et al.*	– during all of the prescription?
e-lak	Is it possible to have > 1 patient active at the same time?
e-lak	Is signing required before the prescription can be sent to the pharmacy?
e-lak	Is it mandatory to sign a termination of treatment?
e-lak, LVFS[18]	Is it mandatory to fill in the cause of prescription?
e-lak	Is it possible to invalidate a prescription?
Author	Is signing mandatory for invalidation?
e-lak	Is the prescription invalidated at the pharmacy?
e-lak	Will the system notify that the invalidation is not made at the pharmacy?
e-lak	Will you get a receipt that the invalidation has been received?
Author	Is the time of duration of treatment included in the prescription?
Author	Is it possible to make a final check of the prescription?
	Is it possible to prescribe drugs in different ways
e-lak, LVFS	– for a limited amount of time?
e-lak, LVFS	– on–off prescription?
e-lak, LVFS	– when indicated?
LVFS	Is it mandatory to fill in the maximum day dose
e-lak, LVFS	– periodically
Author	– after schedule?
e-lak, Bell *et al.*	Is the list of medications the same in in- and outpatient care?
	When making a new prescription, is the following presented clearly?
e-lak, LVFS	– the name of the drug
e-lak, LVFS	– the drug potency
e-lak, LVFS	– the dosage
e-lak, LVFS	– the field of application
e-lak, LVFS	– the prescribed amount
e-lak, LVFS	– the number of dispenses
e-lak, LVFS	– the date of the prescription
e-lak, LVFS	– the name of the prescriber
	If previously prescribed drugs, is the following presented clearly?
e-lak	– the name of the drug
e-lak	– the drug potency
e-lak	– the dosage
e-lak	– the field of application
e-lak	– the prescribed amount
e-lak	– the number of dispenses
e-lak	– the date of the prescription
e-lak	– the name of the prescriber
e-lak	– the date of the termination
e-lak	Are e-prescriptions stored at shutdowns?
e-lak	Will prescriptions be sent automatically after the shutdown?
e-lak	Is it possible to print a paper copy?
e-lak, Bell *et al.*	Are you made aware of disturbances in the e-prescription service?

Source (Reference)	Criteria of usability
	Prescription support
Author	Is it possible to renew all medications with one key tap?
e-lak	Is package size suggested when time of treatment has been stated?
e-lak	Is the prize presented clearly?
e-lak	Is the size of the package presented?
e-lak	Are recommended drugs displayed?
e-lak	Is the prescriber made aware when prescribing a non-recommended drug?
e-lak	Are generic drugs displayed at the prescription?
	Decison support
e-lak	Is the IT support integrated with SIL?[b]
e-lak	Is the drug checked against SIL when re-prescription occurs?
Author	Are there prescription and decision support?
Bell *et al.*	Are warnings being prioritised according to clinical relevance?
Author	– Janus[c]
Author	– FASS[d]
Author	Are there warnings about interactions?
Bell *et al.*	–contraindications?
Author	–allergies?
Author	– warnings about pregnancy, lactation?
Author	Is there coordination between the laboratory test results, kidney–liver function?
Author	Are favourite prescriptions displayed?
Author	How are these updated?
e-lak	Is it possible to see the historical prescription for a single drug?
e-lak	Is this presented by the ATC-code?
e-lak	Is it possible to enter the cause of termination of treatment?
	User-friendliness
e-lak	Is the interface distinct?
e-lak	– self-instructional?
Author	How many mouse clicks are necessary in order to make a new prescription?
Author	How many mouse clicks are necessary in order to make a re-prescription?
Author	Is it possible to make a prescription with only keyboard shortcuts and the tab key?
e-lak	Is it easy to terminate a drug?
Author	Is the CPOE easy to find in the EHR?
Author	Is it easy to prescribe drugs?
e-lak	Is it easy to re-prescribe drugs?
Author	Is it easy to invalidate a prescription?
	Patient support
e-lak	Is it possible to print a paper copy of the medication list?
e-lak	Are the amount prescribed and the number of dispenses shown?

Notes: [a] e-lak Quality is a Swedish network that was formed to develop electronic communication in the pharmaceutical field between healthcare and the National Cooperation of Pharmacies. The network includes representatives from the Swedish Association of regions, private health care providers, municipalities, and pharmacies. This network has formed a description of the basic requirements for an IT support for quality improvement of e-prescription. [b] Swedish Information System for Medicines is a database that ensures the quality of drug information. [c] Janus is a database that contains comprehensive producer-independent drug information, targeted at doctors and paramedics whose purpose is to contribute to evidence-based and cost effective drug therapy. It includes addressing different kinds of interactions. [d] FASS contains quality assured information of registered drugs in Sweden for doctors, patients and veterinarians, provided by the Swedish Pharmaceutical Association Service AB, LIF.